

Development of THALES2 Code and Application to Analysis of the Accident at Fukushima Daiichi Nuclear Power Plant

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Outline of Presentation

- > Overview of THALES2 Code
- > Past Studies with THALES2 Code
- > Application to 1F NPP Accident Analysis
- > Ongoing and Planned Studies
- > Summary



Role of THALES2 Code

- > Integrated severe accident code to analyze source term for level 2 PSA
- > Consideration of major phenomena associated with thermal-hydraulics, in-vessel and ex-vessel melt progression and transportation of FPs

MELCOR

THALES2 THALES for thermal-hydraulics and melt progression
+ ART for transportation of FPs



Source term including uncertainty

Detailed code for analysis of individual phenomena

- ◆ Evaluation for effectiveness of AM measures
 ◆ Proposal of AM measures
 ◆ Analysis of Fukushima Dailchi NPP accident
 ◆ Accident consequence analysis
 ◆ Planning for emergency preparedness
- Coupling or combination

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Brief Description of THALES2 code

Fast running capability

◆ Simplified modeling for thermal-hydraulics and core melt progression

➤ Covering major phenomena for transportation of FPs within

RCS and CV with the exception of chemical reactions

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Past Studies with THALES2 Code

- ➤ Source term analysis for various accident sequences
 - ◆Inputs for accident consequence analysis
- ➤ Uncertainty analysis for source term
- Preliminary coupled analysis with KICHE code for containment iodine chemistry

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Output from Source Term Analysis

Sequence of Events and Environmental FP Release

Time from Accident Initiation (hours)
0 10 20 30 40 50 60

TOW
10 10 10 3 10 2 10 1 10 2

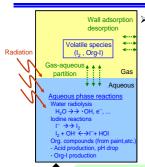
Overpressure
- Controlled release
- Termination
TOUVIW
- Overpressure
- Controlled release
- Termination
- Termination
TOUVIW
- Overpressure
- Controlled release
- Termination
-

- > Identification of major accident sequences (51 sequences) from PSA studies
- > Reduction into 5 groups based on the similarity of accident progression

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Overview of KICHE Code



Analysis for iodine chemistry in LWR CV under severe accident conditions

- ◆ Aqueous phase reactions including water radiolysis and organic iodine formation
 - Mechanistic approach based on reaction kinetics
- ◆ Gas-aqueous partition
- Wall adsorption/desorption
- Dissolution of organic materials from paint
- ◆ Aqueous phase pH variation

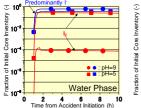
Validation

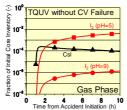
- JNES-JAEA cooperative research
 OECD/NEA BIP (Behavior of Iodine Project)
 OECD/NEA ISP (International Standard Problem)

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Coupled Analysis with KICHE Code

Partitioning of Iodine Species in S/C





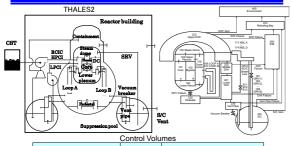
- > Significant dissolution of iodine species in water phase of S/C
- Formation of larger amount of I2 in water phase with lower pH, resulting in volatilization into gas phase
- Importance of pH variation depending on accident progression and applied accident management measures

Application to 1F NPP Accident Analysis

- > Analysis for units 2 and 3 with THALES2 code in parallel with reference analysis using MELCOR code (Ver. 1.8.5)
- > Input preparation based mainly on publicly available information
 - ◆Automatic activation of equipments
 - **♦**Operator actions
 - ◆Accident management measures
- > Assumptions for uncertain parameters
 - ◆Water injection rates
 - ◆Failure location and timing of containment vessel (unit 2)
 - ◆Flood of tsunami water in torus room (unit 2)



Nodalization for Analysis



Control Volumes							
	TAHLES2	MELCOR					
Reactor coolant system	7	20 (included 4 main steam lines and 8 SRV lines) 6 (3 volumes for D/W)					
Containment vessel	4						
Reactor building	1	2					

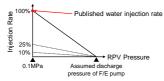
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Conditions of Analysis

	HPCI flow rate*1	F/E flow rate*2	CV failure location	
Unit 2	-	10%	D/W gas phase	
Unit 3	3.5%	25%	S/C venting	

^{*1} Fraction of nominal flow rate taking into account operator action to return a part of HPCI water to CST through test line
*2 Fraction of published information for water injection rate by fire engine pump

Assumed Pressure Dependence of F/E Water Injection Rate



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Sequence of Major Events

Unit in hour

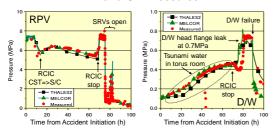
Events	Unit 2		Unit 3	
	THALES2	MELCOR	THALES2	MELCOR
Gap release*1	76.5	76.3	44.3	43.2
Core melt*2	77.7	77.5	44.0	44.3
Failure of lower core support plate	81.0	78.5	46.7	45.3
Failure of lower head	87.6	↓	52.2	ļ

^{*1} Cladding temperature at 1173K *2 Cladding temperature at 2098K (melting point of Zr)



Results of Unit 2 Analysis (1/2)

RPV and CV Pressures

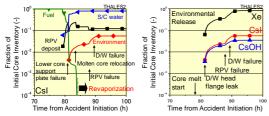


- > Similar results between THALES2 and MELCOR codes
- Good agreement with measured data, but not for D/W pressure after stop of RCIC

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Results of Unit 2 Analysis (2/2)

Distribution and Environmental Release of FPs

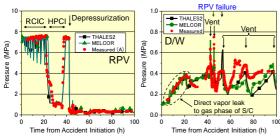


- Significant contribution of revaporization of once deposited FPs onto RPV structures
- Potential for revolatilization of iodine species from water phase of S/C

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Results of Unit 3 Analysis (1/2)

RPV and CV Pressures

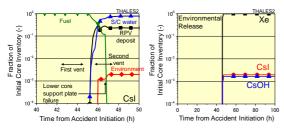


Similar tendency between THALES2 and MELCOR codes except for timing of pressure peak generation in D/W due to RPV failure



Results of Unit 3 Analysis (2/2)

Distribution and Environmental Release of FPs

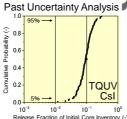


Most release of FPs during the second venting period through S/C

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Ongoing and Planned Studies

- Analysis for OECD/NEA BSAF (Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station) project
- Update of uncertainty analysis for source term with the latest version of THALES2 code and identification of important factors to be improved
- Coupled analysis with full capability of KICHE code including time-dependent pH variation and formation of organic iodine
- Continuous modeling improvement for source term and AM measures and application to evaluation of AM effectiveness



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Summary

- THALES2 code has been developed at JAEA with main target of source term analysis for level 2 PSA.
- Applications of THALES2 code were made to various source term studies, including analysis of the accident at Fukushima Daiichi NPP.
- > Improvement and application of THALES2 code are continued in ongoing and future studies.

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